Project ID: EEMS025

U.S. DEPARTMENT OF ENERGY

SMARTMOBILITY

Systems and Modeling for Accelerated Research in Transportation

National Scale Multi-Modal Energy and GHG Analysis of Inter-City Freight

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Argonne NATIONAL LABORATORY

INL Idaho National Laboratory

BERKELEY LAB

OAK RIDGE National Laboratory

NREL NATIONAL RENEWABLE ENERGY LABORATORY

Project Overview

Timeline

- Project start: Oct. 2016
- Project end: Sept. 2019
- Completion: 25%

Budget

- FY17: $80K/yr

** Funding amount is for this task only, not for the entire pillar*

Barriers

- Limited understanding on national energy impacts of smart technologies on inter-city freight
- Limited understanding on potential energy saving due to mode shift

** Funding amount by lab is for this task only, not for the entire pillar*

Partners

Argonne NATIONAL LABORATORY

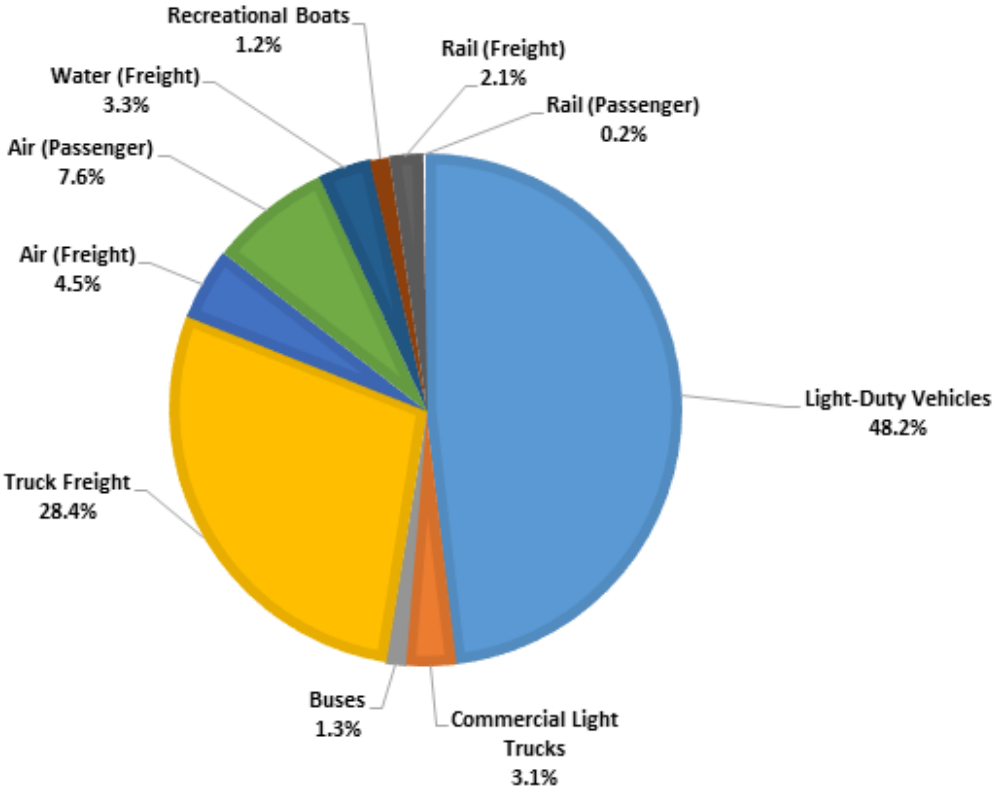
INL Idaho National Laboratory

OAK RIDGE National Laboratory

NREL NATIONAL RENEWABLE ENERGY LABORATORY

Project Overall Objectives/Relevance

- Analyze national level energy and emission impacts of **inter-city** freight due to smart technologies using Argonne's NEAT model



Source: AEO 2016 REFERENCE CASE

Potentially some of the freight energy use and associated GHG emissions be reduced by

1) **Smart technologies** (e.g. platooning)
2) **Mode shift** (shifting from trucks to rail)

Q: How much could be reduced?

Schedule/Milestones

Year	Q	Quarterly Milestone	Progress
FY17	Q2	Preliminary impact quantification of long haul freight energy implications.	Completed
FY 18	Q3	Updated energy impact quantification	In-process

Approach

Based on literature, real-world data and simulation/modeling results

- Work with NREL, ORNL and INL to establish limits to the following factors due to futuristic inter-city freight operations and smart technologies
  - modal efficiencies
  - freight mode shares

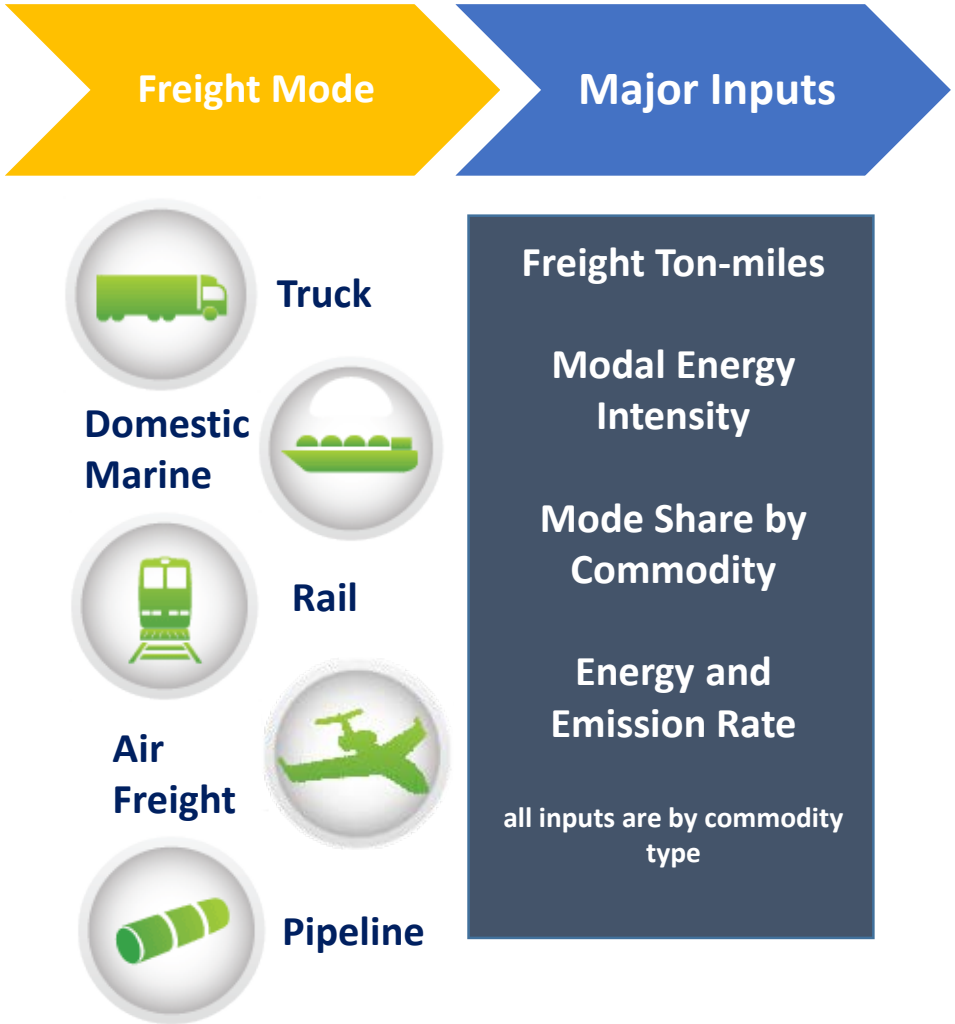
FY17 focus on high level national impacts of low-level automation

- Reviewed literature and Smart CAVs pillar analysis/modeling results to identify:
  - upper limits of truck efficiency due to platooning
  - possible platoonable mileages
- Incorporated results from literature and CAVs pillar analysis to Argonne's NEAT model to quantify possible national energy impacts

NEAT for National Scale Freight Energy Analysis

- Argonne's NEAT model can identify "size of the prize" of **inter-city** freight due to
  - Potential mode shift
  - Improved efficiency (e.g. platooning)
  - Demand changes by commodity
  - Increased alternative fuel use
  - Alternative economic, regulatory, and policy scenarios

- NEAT model is publicly available, annually updated and calibrated to match AEO and FAF projections



Assumptions Used in Our Analysis

Based on literature and SMART MOBILITY results

- ❑ **Platoonable ton-miles** increase from 0% to 65% over the time horizon of 2015 ~ 2040
- ❑ Energy intensity (**BTU/ton-miles**) decrease **4%** for leading trucks and **10%** for following trucks. On average, one leading truck is followed by 3 following trucks
- ❑ Sensitivity analysis: the **platoonable ton-miles** varies from 50% ~ 80% at 2040
- ❑ Analysis horizon: 2016- 2040

All assumptions will be updated when better information is available within the pillar and from other pillars

Research Gaps from Existing Studies

- ❑ Very few studies investigated the truck efficiency change by commodity type
- ❑ Limited studies on the amount of time and distance available for platooning
- ❑ Limited studies on the fuel savings or increase in platoon formation
- ❑ Limited information reported on payload (weight of truck) and commodity types when platooning
- ❑ Limited studies on fuel savings potential of individual trucks making a trip that are a part of platoons along the way
- ❑ Most of the experimental studies have been conducted on empty roads (no traffic congestion) with trucks that are the same weight

Truck Fuel Saving Due to Platooning Varies in a Wide Range (Summary of Literature Review)

- Lead Truck: 2%-7%
- Trail Truck: 3%-16% depending on gap
- Tandem fuel saving: 3%-15% depending on gap and # of trucks

- Trucks should be ordered based on mass for maximum fuel efficiency
- Shorter spaces in between trucks lead to greater fuel savings

- Reported saving are averaged out so that slope of road is not taken into consideration
- Fuel efficiency in the formation of platoons: adjusting speeds for the splitting and merging of platoons is still more efficient that not being a part of a platoon at all

Platoonable Miles/Time Vary by Speed and Continuation Beyond Certain Speed (Summary of Literature Review)

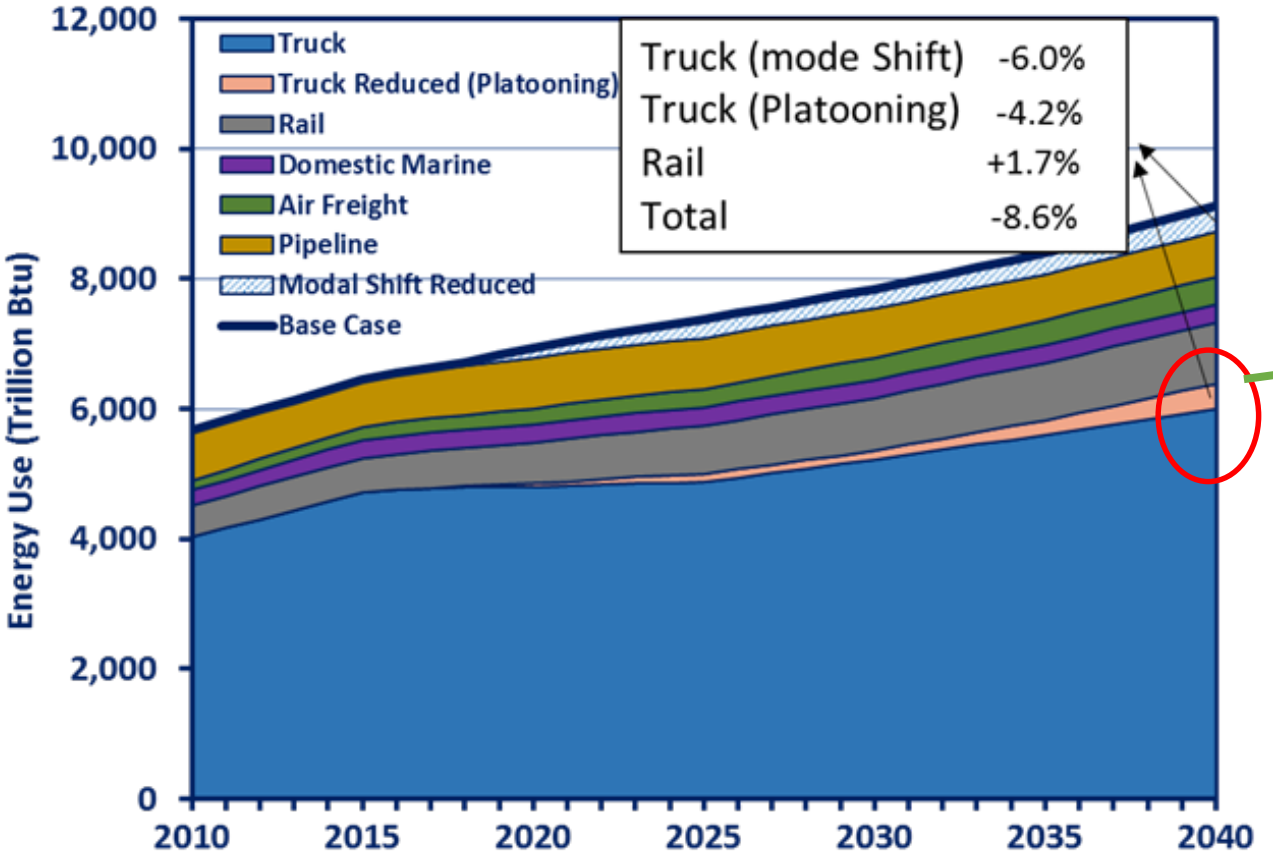
- SMART CAVs/9E NREL report: platoonable miles by time thresholds (amount of time continuously driven above 50 mph)

  20% - 85% platoonable miles (2 min – 90 min)

- FHWA/AUBURN study: developed optimization algorithms to better understand what affects platoon formations
  - Lead truck speed adjustment influences number of platoons could be formed, but increase time delays
  - Energy consumption of accelerating when forming could cancel out the benefits of a platoon
  - Road saturation affects platooning opportunities – more trucks on road within smaller distances between them can lead to more platoon formations

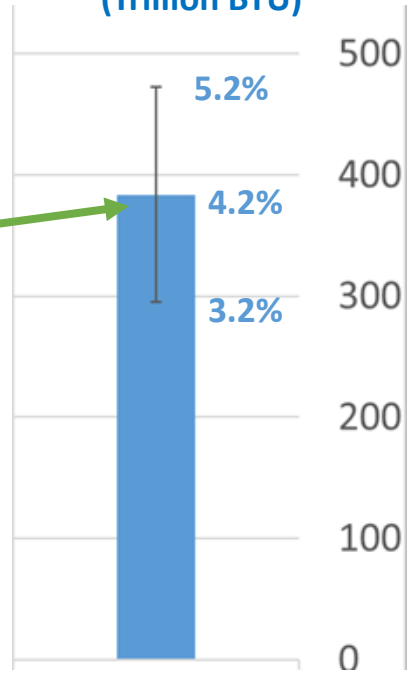
Annual Freight Sector Energy Consumption Could Be Reduced By About 5% Due To Truck Platooning In 2040

Earlier analysis indicates mode shift from truck to rail could reduce truck energy consumption by 6% in 2040



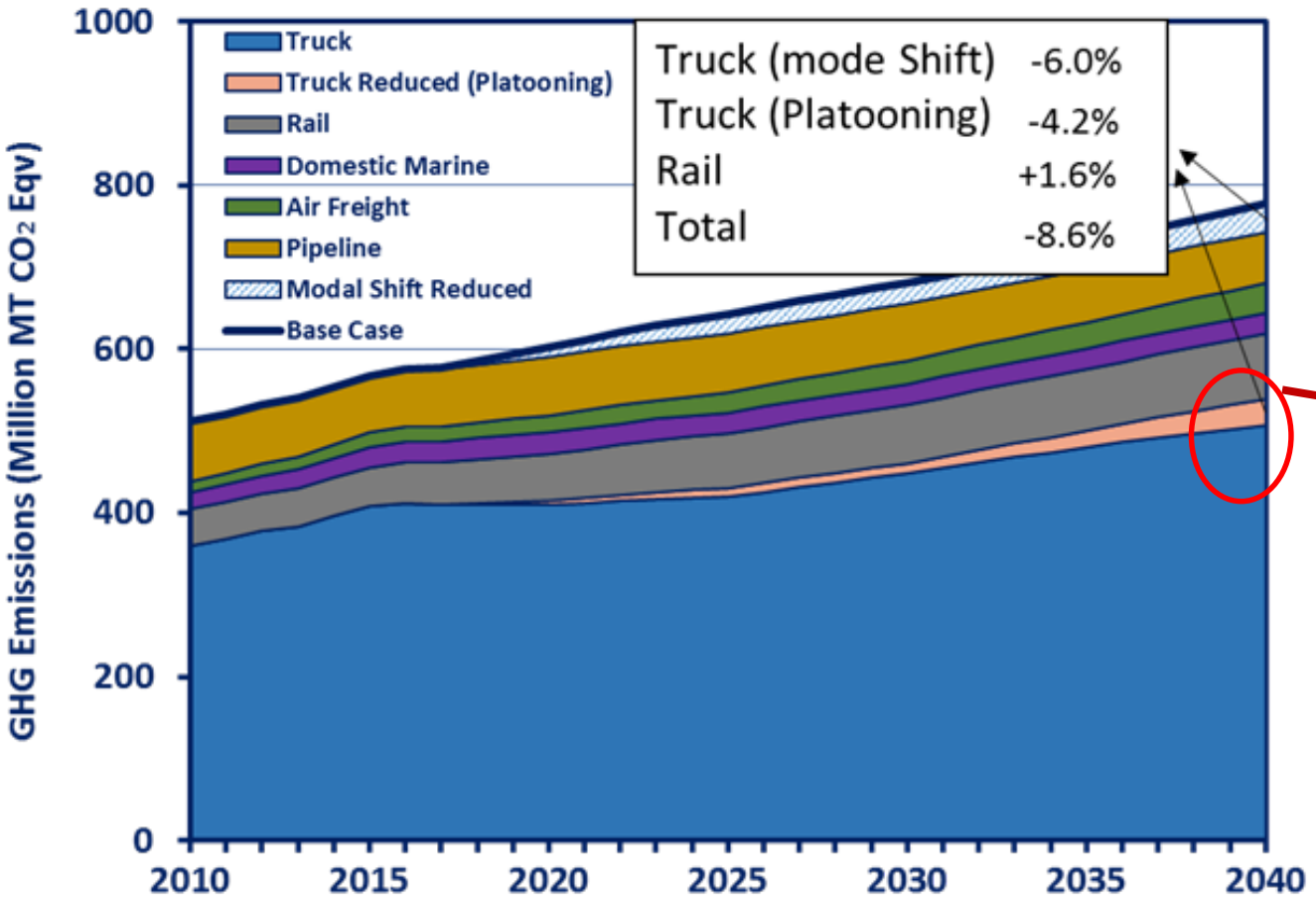
Sensitivity analysis:

Total Energy Saving Range in 2040 (Trillion BTU)



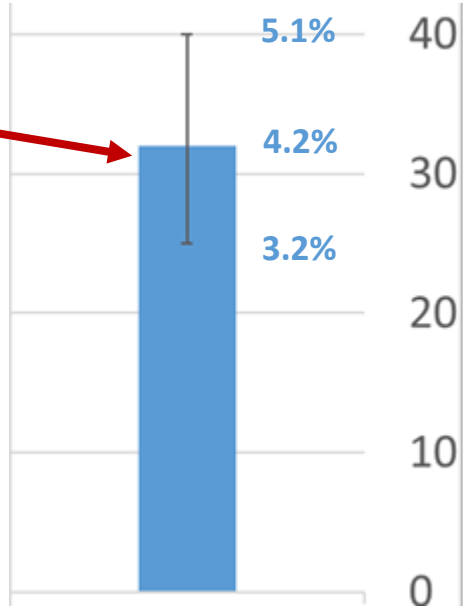
** Compared to AEO 2015 reference case*

Annual Freight Sector GHG Emissions Could Be Reduced By About 5% Due To Truck Platooning In 2040



Sensitivity analysis:

Total GHG Emissions Reduction Range in 2040 (Million MT CO2 Eqv)



** Compared to AEO 2015 reference case*

Collaboration

- Collaborate with Idaho National Laboratory, National Renewable Energy Laboratory and Oak Ridge National Laboratory on data collection and identifying research needs

Remaining Challenges and Barriers

- Lack of real-world freight data with smart technologies
  - Collaboration with various organizations
  - Modeling and simulations to produce needed inputs
- Hard to quantify impacts on freight efficiency and mode shares by commodity type
- Uncertain about h ow smart technologies would affect freight operation cost

Planned/Proposed Future Work

- ❑ Convert fuel saving % to energy consumption per ton-miles (BTU/Ton-miles)
- ❑ Investigate fuel saving by commodity, payload and distance traveled
- ❑ Convert platoonable miles/times to platoonable ton-miles
- ❑ Identify efficiency improvement due to other smart technologies other than platooning, such as better logistic operation
- ❑ Identify future inter-city freight demand due to increasing fast/guaranteed shipping (demand higher than AEO/FAF projections)
- ❑ Incorporated results and data from other members within MM pillar and CAVs pillar analysis to characterize benefits from key Smart Mobility technologies (e.g. FleetDNA, UPS data)

Summary

- Objective of this project is to analyze national level energy and emission impacts of inter-city freight due to smart technologies, with **FY17 focus on high level national impacts of low-level automation: platooning**
- We assumed energy efficiency change and platoonable ton-miles based on literature review and Smart Mobility CAV results
- Preliminary national estimate by NEAT model shows up to 5.2% annual energy reduction due to truck platooning in 2040
- We will develop methodology and assumptions to convert efficiency fuel saving % to energy consumption per ton-miles (BTU/Ton-miles)
- We will continue to work with other labs to establish limits to the following factors due to futuristic inter-city freight operations and smart technologies

THANK YOU!
QUESTIONS?